CHAPTER 1

INTRODUCTION

1.1 Motivation and Problem Statement

The demand for energy is increasing annually in the world as it is a necessary input to sustain living. As a result, obtained from the generalization of agricultural, domestic and industrial activities, the demand for energy has grown dramatically, especially in emergent countries (Baños et al., 2011). International Energy Agency (IEA) had estimated that the global energy consumption in 2012 was 5.6×10^{20} joules. In 1973, the final energy consumption in the world had been reported 54335 terawatt-hours (TWh) meanwhile the figure had rocketed to 104426 TWh in 2012 (IEA, 2014). It can be seen that the global energy consumption had almost been doubled up within 39 years. With the rapid development and modernisation in Malaysia, U.S. Energy Information Administration (EIA) had reported that 120 billion kWh of energy, in the context of electricity, was utilised in 2012, which had a double increase since 2000 (EIA MEIH, 2014). The statistical analysis has strongly proven that the demands for energy globally and locally have swiftly increased and have been projected to grow by 56% between 2010 and 2040 (IEO, 2013).

Currently, Malaysia is having heavy reliance on non-renewable fossil fuels in generating energy. In 2012, Malaysia’s primary energy consumption was majorly contributed by petroleum and natural gas, with estimated shares of 40% and 36% respectively (IEA, 2014). According to the forecasts of fossil fuels reserves in Malaysia, petroleum is estimated to be depleted by 2020, followed by natural gas by 2058 and coal around the year 2066 (Muda & Tey, 2012). As the fossil fuels depletion worrisome is increasing with years, the demand for effective and efficient alternative energy technology, which must be sustainably renewable, is urgent in recent time. The urge of using renewable energy such as solar power, hydro power, wind, biomass, etc. is driven to replenish the exhaustion of fossil fuels. However, alternative energy comes out with various important drawbacks, such as the discontinuity of generation, as most renewable energy resources depend on the climate, which is why their use claims complex design, planning and control optimization methods (Baños et al., 2011). Despite the obvious advantage of its renewable content, there is still a certain gap in exploiting alternative energy efficiently.

Owing to that, there has been interest in the utilisation of biomass for production of environmental friendly biofuels (Mohammed et al, 2011). Biomass refers to products, by-products, residues and waste from forestry, agriculture and related industries, which also includes the non-fossilized and biodegradable organic fractions of industrial and municipal solid wastes (Demirbas, 2011). In Malaysia, the production of palm oil in 2015 was almost 20 million tonnes (MPOB, 2015). The massive production of palm oil and its products has promoted Malaysia to be one of the largest producers and exporters of palm oil products in international market. With the exceptionally large production of palm oil has given the advantage of having huge amount of empty fruit bunches (EFB) too, which is the by-product from crude palm oil mill. A total of 79.3 million tonnes of fresh fruit bunches is processed in 2006 and 17.4 million tonnes of EFB have been generated (Amal, 2008). EFB is categorised as biomass element, which would benefit Malaysia's vision in adopting alternative energy, as biomass is recognised as clean and environmentally friendly fuel source, since the International Energy Agency 2002 reported that most of the emissions come from energy (80%) and agriculture 20%. Biomass can be utilised as an energy resource which can be efficiently achieved by thermo-chemical conversion technology: pyrolysis, gasification or combustion (Mohammed et al., 2011).

Coal gasification has reached its maturity at the moment. In recent years, due to the continuing increase in oil prices, production of liquid fuel from coal has already shown the potential of economical competitive advantage. This is especially true for the low rank coal which is not suitable for direct combustion and coking; producing liquid fuel from these types of coals could be a more viable option (Xu, 2013). However, the utilization of coal creates an environmental issue because of its generation of CO_2 and emission of pollutant substances such as SOx. Hence, alternative feed such as biomass is taken into consideration to replace coal.

However, in fact, it is practically impossible at the moment to completely replace coal with biomass resources because of the low energy value of biomass (Mabizela, 2014). Hence, co-gasification process technology has been a significant research in employing biomass EFB and coal as feedstock to produce clean gas effectively. Co-gasification of coal and biomass has some synergy (Sjöström, 1999). synergistic relationship when used together. The synergistic relationship between coal and biomass is defined as when two or more causes combine together to produce a result that is greater than the sum of its parts. If an amount of coal produces syngas with a certain heating value, and an amount of biomass produces syngas with a different heating value, to say that the two are in synergism with regards to syngas production means that the heating value reached by the combination of both amounts is greater than it would have been if they were gasified apart and both streams of syngas are collected together afterwards (Long & Wang, 2011). This process technology is able to solve the issue of EFB as the waste from the crude palm oil production, meanwhile it can contribute in generating alternative energy.

Co-gasification is an established technology (Ishi, 1982). It refers to the process of converting multiple components of carbon-containing feedstock, comprising both biomass and coal here, under high temperature and high pressure using limited oxygen in gasifier to produce synthetic gas which is to be utilised for other processes such as methanol production, as energy, etc. with the advantage of minimal environmental footprint. There is an apparent knowledge gap in this co-gasification technology using EFB as biomass element and little relevant literature was found. The variant of feedstock ratio of EFB to coal, temperature, the steam to EFB ratio and pressure will be the components to be solved in order to obtain the producer gas in desired range to feed the demand of end users.

Environmentally, biomass is sustainable and hugely carbon neutral as the plants absorb CO_2 during their growth, and thus utilising biomass for energy will be able to reduce the environmental footprint compared to using pure coal (Collot et al. 1999). The problem of environment and economic growth with using co-gasification will be investigated throughout the research in the process simulation of co-gasification system.